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Multifractal Thermal Structure in the Western Philippine Sea Upper Layer

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Upper layer (above 140 m depth) temperature in the western Philippine Sea near Taiwan was sampled using a coastal monitoring buoy (CMB) with attached 15 thermistors during July 28 – August 7, 2005. The data were collected every 10 minutes at 1, 3, 5, 10, 15, and 20 m using the CMB sensors, and every 15 seconds at 15 different depths between 25 m and 140 m in order to observe turbulent thermal structure. Internal waves and solitons were also identified using the empirical orthogonal function analysis. Without the internal waves and solitons, the power spectra, structure functions, and singular measures (representing the intermittency) of temperature field satisfy the power law with multi-scale characteristics at all depths.

Without the internal waves and solitons (turbulence-dominated type), the temperature fluctuation has maximum values at the surface, decreases with depth to mid-depths (60-65 m deep), and then increases with depth to 140 m deep. Such depth dependent (decreasing then increasing) pattern preserves during the internal wave propagation during 1000-1500 GMT July 29, 2005. However, this was altered during the internal soliton propagation to a pattern that increases with depth from the surface to 60 m deep, decreases with depth from 60 m deep to 100 m deep, and increases again with depth from 100 m to 140 m deep. The temperature fluctuation enhances with the internal wave and soliton propagation. Between the two, the internal solitons bring larger fluctuations.

Three types of thermal variability are identified: IW-turbulence, IS-turbulence, and turbulence-dominated. The power spectra of temperature at all the depths have multi-scale characteristics. For the IW-turbulence type and turbulence-dominated type, the spectral exponent β is in the range of (1, 2) and thus the temperature field is nonstationary with stationary increments. For the IS-turbulence type, the spectrum is quite different and the spectral exponent β is less than 1 for the low wavenumber domain. The structure function satisfies the power law with multifractal characteristics for the IW-turbulence type and turbulence-dominated type, but not for the IS-turbulence type. The internal waves increase the power of the structure function especially for high moments. The internal solitons destroy the multifractal characteristics of the structure function. The power law is broken approximately at the lag of 8 min, which is nearly half period of the IS (with frequency of 4 CPH).

The internal waves do not change the basic characteristics of the multifractal structure. However, the internal solitons change the power exponent of the power spectra drastically especially in the low wave number domain; break down the power law of the structure function; and increase the intermittency parameter. The physical mechanisms causing these different effects are also presented.